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## THE RELATION OF MALARIA TO CROP PRODUCTION

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THE principal effects of malaria upon farming are a reduction in the net profits on the crops grown and reduced values from the non-development of farm lands. Herrick (1903) mentions these losses, as applied to southern agriculture, and Howard (1909) emphasizes the economic loss from malaria by figures which are startling. He estimates that there is an annual loss in the United States through this disease of not less than \$100,000,000.

The rural nature of malaria places the larger portion of the loss from the disease upon the farming class. The disease is more prevalent in the south than in other regions of the United States. The higher prevalence in the south is due to the larger areas of swamp and undrained lands, and lands subject to overflow which offer favorable breeding-places for the mosquitoes that convey the disease, to the longer season of high temperatures which favors mosquito development and which increases the length of the active season of the disease, and to the presence in larger numbers of an indifferent race which is tolerant of the disease. Although the losses from malaria have been appreciated for many years, the exact manner in which the disease operates against farm profits is not generally understood.

In 1913 the Bureau of Entomology undertook a detailed study of the relation of malaria to agriculture in the south. The ultimate object of the study is the prevention of malaria on the farm. The investigation is based on the idea that the prevention involves measures for the control of malaria mosquitoes which are practicable under the usual farming conditions. In the absence of definite information on the relation of the disease to farming, the primary work dealt mainly with the exact manner in which malaria operates against the net profits from farm crops. The study is an intensive one and its scope extends no further than the strictly agricultural and biological phases of the problem. The effort is to obtain concrete and fundamental information as a basis for an extensive application of measures for prevention. It is believed that the first step is to secure definite data on the manner in which malaria affects agriculture.

During the course of the investigation it has been determined that the important losses from malaria on a plantation are sustained through the loss in time and the reduced efficiency of the labor at the season of the year when the labor is most needed to work and to harvest the crops.

The prevailing system of plantation labor in the south is the negro tenant system, and the prevention of malaria among the tenants is considered the most important point in the problem of preventing the disease on a plantation. In the tenant system, the family is the unit in contrast to the day-wage system, where the individual is the unit. The family was, therefore, made the unit in the study.

The figures in this paper are based on the conditions that obtained during the season of 1914. The survey work included a detailed study of the 74 tenant families on a plantation and the amount of malaria among them in a region where the plantation operations and endemic malaria are typical. The plantation cultivated 1,800 acres of land, 1,191 acres by the tenant system and 609 acres under the direct supervision of the plantation management by labor drawn from the tenant families on a day-wage basis. The tenants averaged 16 acres per family. The 74 families show a total of 299 individuals, or an average of 4 persons per family.

The crops grown on the plantation consisted of 743 acres of cotton and 448 acres of corn under the tenant system and 80 acres of cotton, 209 acres of corn, 200 acres of oats, 70 acres of cow-peas and 50 acres of lespedeza hay under the day-wage system.

All time was reduced to adult time or man days of labor. The time of a male over 18 years of age was figured as full time, a male from 12 to 18 years as one half adult time and from 8 to 12 years as one fourth. The time of a female was figured as one half the time of a male. No account was taken of the time under 8 years of age. Reducing all the available labor on the plantation to adult time, there is an equivalent of 2 adults to each of the 74 tenant families.

The actual time lost through malaria consisted of 970 days for those treated by the plantation physician, 487 days in those cases not reporting to the physician, and 385 days lost by non-malarial members of the families in attending those who had the disease. There was a total loss of 1,842 days. This reduced to adult time, not taking account of illness in members of the families under eight years of age, amounts to 1,066 days of adult time from May to October, inclusive. The time lost averaged 14.4 adult days for each family. There were 166 cases of malaria in 138 persons out of the total of 299 members of the tenant families. There was a loss of time equivalent to 6.42 adult days for each case of malaria. The seasonal distribution of the cases of malaria was as follows: May, 15 cases; June, 31 cases; July, 25 cases; August, 38 cases; September, 36 cases, and October, 21 cases. The number of adult days lost through malaria, then, is 96 days for May, 199 days for June, 161 days for July, 244 days for August, 231 days for September and 134 days for October.

The effect of loss of time upon the crops can be measured by the

ratio of the time lost through malaria to the difference between the available labor and labor requirements of the crops. It must be conceded that any loss of labor from any cause in the face of any surplus labor that exceeds the time lost, can not be considered as operating against the crops. In the case of no surplus labor, or an actual deficiency, any time lost through malaria reacts at once upon the crops, the seriousness of the neglect to the crops depending upon the period in the planting, cultivating or harvesting the crops that the lost time occurs. It will be shown that the time lost through malaria during at least four months of the year falls at periods when there is a deficiency of labor and when the demands of the crops for labor are greatest. For cotton, the principal crop, these periods are chopping and hoeing, boll-weevil control and picking. Any neglect at these periods is a very serious matter and might mean total failure of a crop.

The available days for field work depend not only upon the number of adult laborers on the plantation, but also upon the available days per month when field work is possible. These two factors decide the available days of adult labor for field work. Mr. M. B. Oates of the Office of Farm Management of the Department of Agriculture has furnished the writer the following estimate of available days per month for field plantation work as determined by a study of estimates obtained by him from 50 plantation managers in the Red River region of northwest Louisiana.<sup>1</sup>

Month	Days	Month	Days	Month	Days	Month	Days
Jan.....	12.0	April.....	15.3	July.....	21.5	Oct.....	19.7
Feb.....	11.9	May.....	18.3	Aug.....	21.0	Nov.....	16.9
March....	14.5	June.....	19.1	Sept.....	19.4	Dec.....	12.6

The fallacy of figuring total days of adult labor per month on a basis of a 30-day month is evident. The factors of Sundays, holidays and climate determine the number of days available for field work during any month. The error would be as great to reduce all labor on the plantation to terms of adult labor and use this figure in obtaining the days of adult labor available. With 74 families averaging 2 adults per family there would be indicated a total of 148 adult days for every day in the year, 4,440 days adult labor available per month or the great total of 53,280 man-days of labor per year. Mr. Oates, on the basis of estimates from 72 plantations, finds that in this region 13.29 adult days of man labor, not including horse labor, are required per acre of cotton. On this basis the above figure shows that this plantation has an amount of labor sufficient to work over 3,200 acres of cotton, a condition which does not exist. The above table by Mr. Oates eliminates the error in

<sup>1</sup> The region included in the estimates is within the 50-inch rain belt. Madison Parish, where this study is located, has a normal rainfall of 51 inches.

days available for field work. It remains to consider the error in number of adults available for labor.

The object is to determine the relation of time lost through malaria to the total time available and to the time required by the crops. In considering the time available it will be necessary to eliminate the effect of malaria upon the efficiency of the labor. Howard (1909) estimates that one fourth of the productive capacity of an individual suffering with an average case of malaria is lost. One hundred and thirty-eight persons out of a total of 299 suffered from malaria during the crop season. Not taking account of the cases in children under 8 years of age and the time lost by adult non-malaria persons in attending those who were sick, the equivalent of the time of the malaria people is equal to the time of 74 adults. A reduction of 25 per cent. in the efficiency of 74 adults equals the total loss of the time of 18.5 adults. An average of 2 adults per family would indicate a loss equivalent to the total time of 9.25 families.

On the basis that every man, woman and child worked every available day in the field there would be available the time of 64.75 families. To figure on this basis would be as great an error as it would be to figure that there were 30 days available for field work every month in the year. There would be no day when every available person over 8 years of age would be in the field and all the persons in the field would not put forth maximum effort every day throughout the year. It is estimated that for these reasons the available labor would be reduced at least 25 per cent. This would mean that instead of 64.75 families, there would be only 48.57 families available. With an average of 2 adults per family, there appears to be available the equivalent of 97.14 adults. However, other factors act to reduce the available labor. Account must be taken of those who have passed the age limit for work in the field, the "pensioners" of the plantation. A funeral will keep practically all the laborers out of the field for all or a part of a working-day. Other diseases aside from malaria keep the laborers at home on working-days. It is estimated that the equivalent of one adult out of every ten would not be available for these reasons. The available man labor on the plantation has been figured on the basis of 90 adults.

Taking 90 adults as representing the available labor and using Mr. Oates's figures on the days available per month for field work, we have the following man days available per month for field work on this plantation.

Month	Days	Month	Days	Month	Days	Month	Days
Jan.....	1,080	April.....	1,337	July.....	1,935	Oct.....	1,773
Feb.....	1,071	May.....	1,647	Aug.....	1,890	Nov.....	1,521
Mar.....	1,305	June.....	1,719	Sept.....	1,746	Dec.....	1,134

The field operations and the man labor requirements for cotton, corn and oats in north Louisiana are shown in the following table which has been prepared from figures which were also furnished by Mr. Oates.

FIELD OPERATIONS AND MAN LABOR REQUIREMENTS FOR CROPS<sup>2</sup>

Crop	Operations	Season (Average)	Days Labor per Acre
Cotton.....	Cut stalks.....	Dec. 28 to Feb. 4	.13
	Break and bed.....	Jan. 14 to Mar. 16	.68
	Harrow or drag.....	Feb. 6 to Mar. 24	.14
	Plant.....	Mar. 31 to Apr. 19	.13
	Cultivate and hoe....	Apr. 13 to Aug. 4	5.43
	Pick and haul.....	Aug. 29 to Dec. 7	6.78
	Total for cotton.....		13.29
Corn.....	Cut stalks.....	Dec. 26 to Feb. 3	.12
	Break and bed.....	Jan. 3 to Mar. 2	.80
	Harrow and drag.....	Feb. 9 to Mar. 20	.16
	Lay off rows.....	Feb. 21 to Mar. 19	.13
	Plant.....	Mar. 5 to Mar. 29	.14
	Cultivate.....	Mar. 26 to June 21	1.21
	Thin or hoe.....	Mar. 24 to June 18	1.07
	Plant peas.....	May 28 to June 18	.12
	Harvest.....	Sept. 13 to Nov. 3	.84
	Total for corn.....		4.59
Oats (threshed)....	Break.....	Sept. 21 to Nov. 8	.64
	Harrow.....	Sept. 25 to Nov. 8	.22
	Sow or drill.....	Oct. 11 to Nov. 16	.09
	Cut.....	May 28 to June 9	.16
	Shock.....	May 28 to June 9	.32
	Haul and thresh.....	June 20 to July 10	.71
	Haul grain.....	June 22 to July 15	.19
	Total for oats.....		2.33

As the labor involved in the control of the cotton boll weevil must be considered in this study, the period for this operation and the labor required are necessary. These have been estimated for this region by Mr. W. D. Hunter. The period of the operation averages from May 1 to June 30. The labor required is equal to at least one third of the labor requirements for hoeing cotton. This amounts to 1.12 man days labor per acre for boll-weevil control work.

The accompanying chart shows the seasonal distribution of the labor, by crops, from the estimates of averages by Mr. Oates, including the operation for boll-weevil control in cotton furnished by Mr. Hunter. (See chart I.). No account has been taken of the 70 acres of cow-peas and the 50 acres of lespedeza hay in arriving at the labor requirements

<sup>2</sup> The figures on cotton and corn are determined from estimates by 72 planters of northwestern Louisiana. Those on threshed oats are from estimates of 9 planters in the same region. The region is in the same rain and frost belts as the one in which this study is located.

on this plantation, as figures on these crops are not available for this particular region.

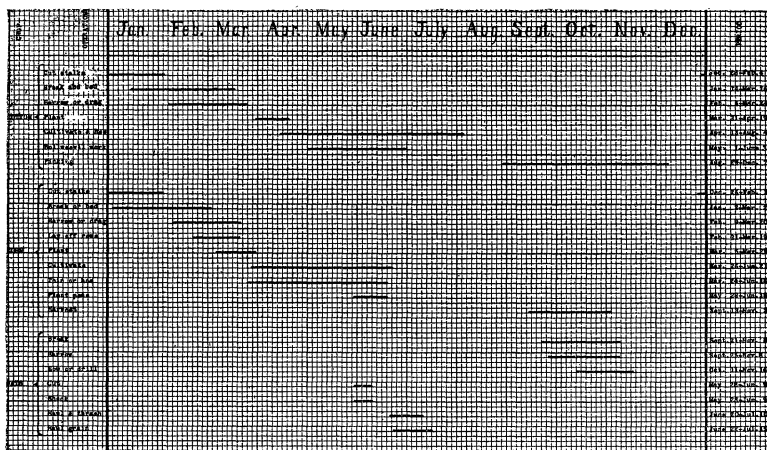


CHART I.

The following table gives the labor requirements on this plantation, distributed in terms of days of adult labor required per month, for 823 acres of cotton, 657 acres of corn, and 200 acres of oats.

As an example, the operation of cutting stalks in cotton fields will serve to show how this distribution was made. Cutting stalks requires .13 man days per acre. On 823 acres this would amount to a total of 107 days. The period when this work is done is from December 28 to February 4. On the basis of 12.6 days during December when field work is possible, there would be available 1.21 days for field work for the 3 days in December. There would be 12 days available for January and 1.7 days for the 4 days in February. The 107 days of adult labor required would have to be done in a period of the sum of these available days, or a total of 14.91 days. To do this would require the time of 7.17 adults. By assigning the days per month on the basis of the days available per month for field work, there is obtained a requirement of 9 days of man labor in December, 86 in January and 12 in February for cutting stalks. The operations for all crops were figured in this manner.

The accompanying chart (see chart II.) illustrates the relation of malaria to crop production by comparing the available labor, the labor required for the crops, including the labor for boll-weevil control in cotton, with the time lost through malaria. It shows that malaria is a serious handicap to the plantation during the months of May, June, September and October. During these months the operations are cultivating, hoeing, boll-weevil control and harvest. Maximum labor is required during all of these periods. There is a total loss of 660 adult days through malaria, in excess of any surplus time, during these 4 months.

DAYS ADULT LABOR REQUIRED FOR CROPS, DISTRIBUTED BY MONTHS<sup>3</sup>

Crop	Operations	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Cotton	Cut stalks.....	86	12	...	...	...	...	...	...	...	...	...	9	107
	Break and bed..	142	257	161	...	...	...	...	...	...	...	...	...	560
	Harrow or drag..	...	52	63	...	...	...	...	...	...	...	...	...	115
	Plant.....	...	...	5	102	...	...	...	...	...	...	...	...	107
	Cultivate and hoe	...	...	...	551	1,164	1,216	1,367	171	...	...	...	...	4,469
	Pick and haul...	...	...	...	...	...	...	...	112	1,614	1,638	1,406	810	5,580
	Total for crop	228	321	229	653	1,164	1,216	1,367	283	1,614	1,638	1,406	819	10,938
	Boll weevil control.....	...	...	...	...	451	471	...	...	...	...	...	...	922
	Total for cotton.....	228	321	229	653	1,615	1,687	1,367	283	1,614	1,638	1,406	819	11,860
Corn	Cut stalks.....	62	7	...	...	...	...	...	...	...	...	...	10	79
	Break or bed....	43	448	35	...	...	...	...	...	...	...	...	...	526
	Harrow or drag..	...	49	56	...	...	...	...	...	...	...	...	...	105
	Lay off rows....	...	29	56	...	...	...	...	...	...	...	...	...	85
	Plant.....	...	...	92	...	...	...	...	...	...	...	...	...	92
	Cultivate.....	...	...	38	247	295	215	...	...	...	...	...	...	795
	Thin or hoe.....	...	...	48	225	270	160	...	...	...	...	...	...	703
	Plant peas.....	...	...	...	...	9	70	...	...	...	...	...	...	79
	Harvest.....	...	...	...	...	...	...	...	...	187	336	29	...	552
	Total for corn..	105	533	325	472	574	445	...	...	187	336	29	10	3,016
Oats (Threshed)	Break.....	...	...	...	...	...	...	...	...	25	84	19	...	128
	Harrow.....	...	...	...	...	...	...	...	...	5	31	8	...	44
	Sow or drill....	...	...	...	...	...	...	...	...	...	11	7	...	18
	Cut.....	...	...	...	...	8	24	...	...	...	...	...	...	32
	Shock.....	...	...	...	...	15	49	...	...	...	...	...	...	64
	Haul and thrash.	...	...	...	...	...	68	74	...	...	...	...	...	142
	Haul grain.....	...	...	...	...	...	12	26	...	...	...	...	...	38
	Total for oats..	...	...	...	...	23	153	100	...	30	126	34	...	466
Summary	Total for cotton..	228	321	229	653	1,615	1,687	1,367	283	1,614	1,638	1,406	819	11,860
	Total for corn...	105	533	325	472	574	445	...	...	187	336	29	10	3,016
	Total for oats...	...	...	...	...	23	153	100	...	30	126	34	...	466
	Grand total...	333	854	554	1,125	2,212	2,285	1,467	283	1,831	2,100	1,469	829	15,342

Making allowance for the time lost on days when field work was not possible, there was a loss of 420.75 adult days which amounted to actual neglect. During these 4 months there are 76.5 days available for field work. The loss represents that of 5.5 adults out of a total of 90 available adults. The actual available adult time per family is 1.21 adults. The time lost is the equivalent to that of 4.54 families. Adding to this the effect of malaria on the efficiency of the labor, amounting to the time of 9.25 families, the survey shows that in the absence of malaria this plantation could operate with the same net returns on the labor of 60.21 tenant families, instead of the 74 families required in the presence of malaria.

<sup>3</sup> On the basis of 823 acres of cotton, 657 acres of corn, and 200 acres of oats.



Herrick (1903) says, in writing of the effect of malaria upon southern agriculture, that "to induce a people to use a remedy it must first be shown that a remedy is very much needed." It is the purpose of the Department of Agriculture to place the prevention of malaria on the farm upon a business basis. It remains to show what malaria means to a cotton planter in so many dollars and cents.

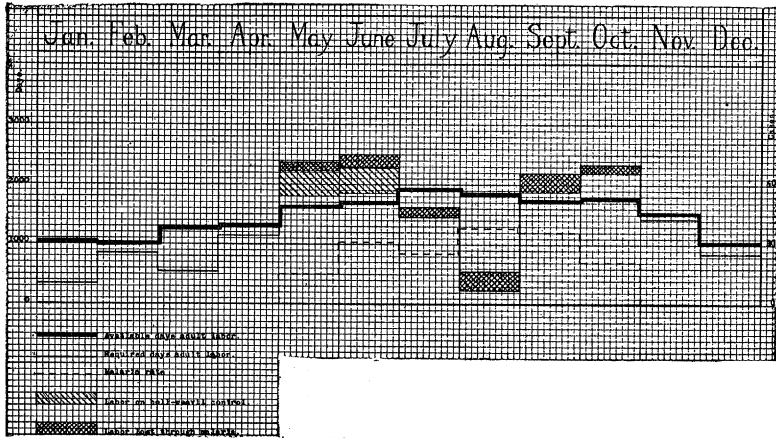


CHART II.

Each family cultivated an average of 16 acres. The plantation depended upon the tenants for labor to cultivate an average of 8.23 acres each on the day-wage basis. This amounts to a total of 24.23 acres to be cultivated by the labor represented in each tenant family, an equivalent of 13.51 acres of cotton. The total loss of the time of 13.79 families is equal to that of the total crop on 186.3 acres of cotton. With an average yield of one half of a bale of cotton per acre, this would equal a total loss of 93.15 bales of cotton. Allowing \$70 a bale for the lint and seed, this would amount to \$6,520.50.

The amount of share varies under the tenant system. In general, though, the plantation management furnishes the land, cabin, mules, feed, implements and fertilizer, and advances to the tenant subsistence and seed. Under this arrangement the plantation receives one half of the crop. Against all this the tenant places only his labor. Any reduction in the yield falls largely upon the owner, since he loses not only his one half of the crop, but a proportion of the advances. In a failure of the crop, the owner loses his one half and the use of the land, cabin, mules and implements, plus all advances to the tenant. The most that the tenant stands to lose is his labor. Not allowing for days when field work was impossible and on the basis of the prevailing day wage of \$1.00 per day, this amounts to \$660. The net loss to the owner is then \$5,860.50.

The actual available adult time in each family equals 1.21 man days. The actual number of available days for field work during the four months under consideration equals 76.5 days. A loss of time equivalent to the total loss of 13.79 families is equal to the loss of 1276.47 man days during these periods, when there was no surplus labor. There were 420.75 days lost through sickness and a loss of 855.72 days due to reduced efficiency. Each day of neglect amounted to a total loss of \$5.11, being a loss of \$4.11 to the owner and \$1.00 to the tenant. The conclusion is that a loss equivalent to one day of man labor through malaria on this plantation, when the crops were in need of attention, and when there was no surplus labor, amounted to a net loss of \$5.11 in the crop returns. Approximately \$2,200 was lost through sickness and \$4,300 through inefficiency from malaria.

The above survey was made in Madison Parish, Louisiana. The common house-frequenting *Anopheles* in this region is *Anopheles quadrimaculatus* Say. *Anopheles punctipennis* Say is common in nature while *Anopheles crucians* Wied., was encountered only in very limited numbers. All three forms of the malaria parasite have been found to occur in this region, namely, tertian, estivo-autumnal and quartan, prevailing in the order named. The work was done in cooperation with the Maxwell-Yerger Co., Dr. Wm. P. Yerger, and Mr. Alexander Clark, Manager of Hecla plantation, Mound, La. The *Anopheles* determinations were made by Mr. F. Knab, of the U. S. National Museum. The blood examinations were made by Mr. J. K. Thibault, Jr., of this Bureau. Mr. Oates, of the Office of Farm Management of this department, furnished the data on the periods of the plantation operations, the available days per month for field work and the labor requirements of the crops.

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